of the tactile display and an electronic interface for communicating the touch sensing information to the computing device.

[0019] **FIG. 8** illustrates an actuator assembly similar to FIGS. **6**A-C, except that the individual rods may include strain gauges coupled through a wire to a separate input/output device of the computing device.

[0020] **FIG. 9** is a block diagram of one embodiment of the invention allowing direct electronic communication between the tactile display and the computing device.

[0021] **FIG. 10** is a cross-sectional side view of three gel cavities is accordance with a further embodiment of the invention attached to electronic means.

[0022] The invention will now be described in more detail by example with reference to the embodiments shown in the Figures. It should be kept in mind that the following described embodiments is only presented by way of example and should not be construed as limiting the inventive concept to any particular physical configuration.

DETAILED DESCRIPTION

[0023] As used herein, "handheld computing device" or "handheld personal computer" (H/PC) means a small general computing device having a processing unit that is capable of running one or more application programs, a display, and an input mechanism that is typically something other than a full-size keyboard. The input mechanism might be a keypad, a touch-sensitive screen, a track ball, a touch-sensitive pad, a miniaturized QWERTY keyboard, or the like.

[0024] **FIG. 1** is an illustration of a handheld personal computer, specifically a personal digital assistant (PDA) **20**, such as the IBM WorkPad® c3 from International Business Machines. However, the invention is compatible with other brands and types of handheld personal computers, such as a personal organizer, a palmtop computer, a computerized notepad, or the like.

[0025] Handheld computing device **20** has a casing **22** and an LCD (liquid crystal display) **28** with a touch-sensitive screen mounted in the casing **22**. A stylus **30** may be used with the device to enter data through the touchscreen display **28**. The handheld computing device **20** can also be implemented with a wireless transceiver (not shown) such as an IR (infrared) transceiver and/or an RF (radio frequency) transceiver.

[0026] **FIG. 2** is a block diagram showing the functional components of the handheld computing device **20**. It has a processor **60**, a memory **62**, a display **28**, and an optional keyboard **32**. The memory **62** generally includes both volatile memory (e.g., RAM) and non-volatile memory (e.g., ROM, PCMCIA cards, etc.). An operating system **64** is resident in the memory **62** and executes on the processor **60**. The H/PC **20** preferably runs the Windows® CE operating system from Microsoft Corporation. This operating system is a derivative of Windows® brand operating systems, such as Windows® 95, that is specially designed for handheld computing devices. However, the handheld computing device may be implemented with other operating systems.

[0027] One or more application programs **66** are loaded into memory **62** and run on the operating system **64**. Examples of applications include email programs, scheduling programs, PIM (personal information management) programs, word processing programs, spreadsheet programs, Internet browser programs, and so forth.

[0028] The H/PC **20** has a power supply **70**, which is implemented as one or more batteries or fuel cells. The power supply **70** might further include an external power source that overrides or recharges the built-in batteries, such as an AC adapter or a powered docking cradle.

[0029] The H/PC **20** is also shown with an optional built in audio generator **74** and auxiliary electrical outlet **72** coupled to the power supply **70**. Preferably, the auxiliary outlet **72** is directly coupled to the power supply **70** so that a peripheral device may remain on for a duration dictated by the peripheral device even though the H/PC processor and other components might shut down to conserve battery power.

[0030] **FIG. 2** also shows the apparatus **100** of the present invention. The apparatus **100** includes an imaging device **102** and a tactile display **104**. The imaging device **102** is shown in alignment with the display **28** of the H/PC **20** in order to receive light that is either emitted from the display (such as a CRT) or reflected off of the display (such as an LCD). It should be recognized that the alignment may be maintained in any fashion, such as attaching or fastening the apparatus **100** to the casing **22** of the H/PC **20**, such as with straps, clips, or screws. While the apparatus **100** may have its own power supply or power cord for coupling to an electrical outlet, the apparatus **100** is shown coupled to the power supply **70** of the H/PC **20** through the auxiliary outlet **72**.

[0031] **FIG. 3** shows a personal computer system **50**, such as an IBM PS/2®, that includes a display device **52** (such as a monitor), a display screen **54**, a cabinet **56** (which encloses components typically found in a computer, such as CPU, RAM, ROM, video card, hard drive, sound card, serial ports, etc.), a keyboard **58**, a mouse **60** and a modem, router or network card **62**. Mouse **60** may have one or more buttons or control devices, such as buttons **66**. The computer preferably has a browser and some type of communication device such as modem **62** that allows computer system **50** to be connected to the Internet.

[0032] **FIG. 4** illustrates an exemplary system architecture for a computer system **100**, such as the personal computer system **50** of **FIG. 3**, on which the invention may be implemented. The exemplary computer system of **FIG. 4** is for descriptive purposes only. Although the description may refer to terms commonly used in describing particular computer systems, the description and concepts equally apply to other systems, including systems having dissimilar architectures.

[0033] Computer system **100** includes a central processing unit (CPU) **105**, which may be implemented with a conventional microprocessor, a random access memory (RAM) **110** for temporary storage of information, and a read only memory (ROM) **115** for permanent storage of information. A memory controller **120** is provided for controlling RAM **110**.

[0034] A bus **130** interconnects the components of computer system **100**. A bus controller **125** is provided for